RECONSTRUCTING HED PARENT BODY MAGMATISM FROM ORTHOPYROXENES IN DIOGENITES. C.K. Shearer, G. Fowler, and J.J. Papike,. Institute of Meteoritics, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico, 87131-1126.

INTRODUCTION. Diogenites have long been recognized as a major constituent of the HED meteorite group. Yet, their remarkable monotonous mineralogy [1,2,3,4] has limited the extent diogenites have been used to reconstruct HED parent body (HEDPB) magmatism. Several papers exploring the trace element characteristics of diogenites [2,3,4] have identified trace element systematics that appeared to mimic simple magmatic processes involving large degrees of fractional crystallization (FC). This appears highly unlikely. Our goal is to explore other potential processes for the chemical variability of orthopyroxenes in diogenites and the relationship of diogenites to other HED lithologies.

APPROACH. We are using two different and complimentary approaches to evaluate HED magmatism models: (1) calculate major element melting models using computational evaluations of melting and melting processes and (2) trace element modeling of partial melting using calculated diogenitic melt compositions [4]. The major element modeling of the EPB melting was done by using the MELTS program developed and provided by Mark Ghiorso [5]. In our calculations, we used 25 different bulk EPB mantle compositions. Conditions under which these calculations were made are as follows: Temperature 1700 to 800 degrees C, Pressure = 500 bars, and oxygen fugacities of iron-wustite (IW), IW+1, and IW+2. Further, we combined estimates made by MELTS with the methodology of Hanson and Langmuir [6] to calculate Mg# in the residua and melts during partial melting. Based on the residuum mineralogy calculated by MELTS and observed by experimental melting studies [7,8,9,10] and the trace element characteristics of the diogenitic liquids [4], we used equilibrium and fractional melting equations to evaluate possible melting processes on the EPB.

DISCUSSION. Using these approaches, we evaluated the orthopyroxene data within the context of numerous crystallization and partial melting models:

(1) Fractional Crystallization: As demonstrated by pervious studies [2,3], extremely high degrees of fractional crystallization are required to account for the trace element abundances in the parental magmas for diogenites. Mittlefehldt [2] suggested that an increase in $D^{\text{mineral/melt}}$ by a factor of three would lower the extent of FC needed to produce the trace element variability in diogenites. Although a three fold increase in $D^{\text{mineral/melt}}$ for Ti and Yb results in a compression of the overall range in calculated melt compositions, to calculate the extent of FC represented by this array the same change in $D^{\text{mineral/melt}}$ is required. Therefore, the overall FC required to produce this trajectory is still extremely high. Therefore, it appears likely that the diogenites represent FC products of several distinct parent magmas.

(2) Batch Melting of a Homogeneous Source: The orthopyroxene data cannot be accounted for by low to moderate degrees of partial melting of a homogeneous EPB mantle. Partial melting of such a source can account for the relatively high Mg# of the calculated parental magmas. Depending on the bulk composition low (5%) to moderate (to 30%) degrees of partial melting will consume plagioclase in the residuum and will produce batches of magma with similar Mg#. However, as illustrated in Figure 1, if a single bulk EPB mantle is melted, the range in incompatible elements in the calculated diogenitic magmas can only be explained by a very extensive range in melting (5% to 90%). In addition, it would suggest that the parental magmas to many of the diogenites are produced by lower degrees of partial melting than the parental magmas to the eucrites.

(3) Fractional Melting of a Homogeneous Source: Variable and prior extraction of a series of eucritic melts from an HED parent body mantle will produce viable sources for magmas parental to the diogenites. As illustrated in Figure 2, small to moderate degrees of fractional melting can account for the extent of diogenitic incompatible element variability. There are two requirements for this model. The first is that $D^{\text{mineral/melt}}$ must change approximately three orders of magnitude. This is required not to adjust the extent of melting-crystallization, but to limit the compositional variability of the diogenitic magmas as shown in Figure 3. Second, some of the magmas parental to the diogenites must also be parental to eucritic magmas.

(4) Melting of a Heterogeneous Source: The wide variability observed in the magmas parental to the diogenites and in particular the incompatible element enriched diogenites may be attributed to the large original variability in material accreting to the EPB. Heterogeneous accreationary models [10] provides a wide compositional range of material. Inefficient mixing of these sources may also be responsible for generating the Fe/Mn and the oxygen isotopic signature of the HED meteorites [10].

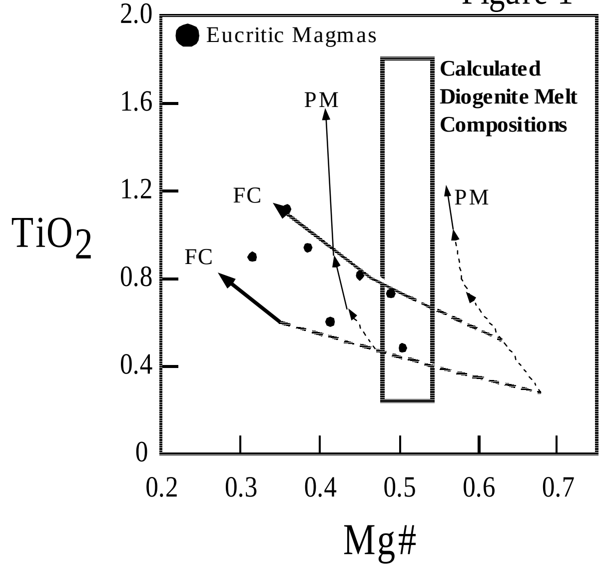
(5) Large Degrees of Partial Melting: Generation of a HED magma ocean and subsequent FC would result in the production of magmas capable of crystallizing orthopyroxenes with high Mg# similar to those found in both diogenites and howardites. High degrees of partial melting would have at least four problems concerning the incompatible element characteristics calculated for the diogenitic magmas. First, high degrees of partial melting is not consistent with a wide variation in incompatible elements. Production of magmas with a wide range of incompatible element concentrations is best attributed to low degrees of partial melting. Second, production of a cumulate orthopyroxenite layer through FC requires 90% crystallization of the magma ocean and would be buried too deep within the EPB to be sampled. Third, high degrees of partial melting tend to homogenize compositional heterogeneities in the source through magma mixing. Fourth, residuum magma resulting from the FC of a magma ocean would not be equivalent to eucrites .

CONCLUSIONS: The diogenites represent orthopyroxene cumulates resulting from the FC of a series of compositionally distinct basaltic magmas. The best way to generate this suite of basaltic magmas is through either moderate degrees of fractional melting of an initially homogeneous source or partial melting of a heterogeneous source.

REFERENCES. [1] Bowman L.E. et al. (1995) LPS XXVII 147-148. [2] Mittlefehldt D.W. (1994) GCA, 58, 1537-1552. [3] Fowler G.W. et al. (1994) GCA, 58, 3921-3929. [4] Fowler G.W. et al. (1995) GCA, 59, 3071-3084. [5] Ghiorso M.S. et al. (1994) EOS 75, 571-576. [6] Hanson and Langmuir (1978) GCA 42, 725-741. [7] Jones J.H. et al. (1994) LPS XXV, 639-640. [8] Jurewicz A.J.G. et al. (1995) GCA, 59, [9] Stolper, E. (1977) GCA 41, 587-611. [10] Boesenberg, J.S. and Delaney, J. S. (1994) Lunar and Planetary Science XXV, 135-136.

Figure 1. The relationship between Ti and Fe. FC represents fractional crystallization trajectories. PM represents partial melting trajectories. Solid lines represent melts that are saturated with plagioclase. Selected eucrites are plotted on diagram. The compositional field for melts parental to diogenites are also shown. The field is based on the assumption that $D^{mineral/melt}$ remains constant during orthopyroxene crystallization. **Figure 2.** Ti (wt%) plotted against Yb (ppm) for fractional melting of a single bulk composition. Calculated diogenite melt compositions from opx data are represented by filled circles [4]. Model melt compositions are shown in open circles and indexed to both the percent melting and the percent of prior melt extraction (R=5,10,15%). Residuum compositions are shown in filled squares and indexed to the percent partial melting. **Figure 3**. Same as figure 1 except the field is based on the assumption that $D^{mineral/melt}$ changes three fold during orthopyroxene crystallization.

Figure 1



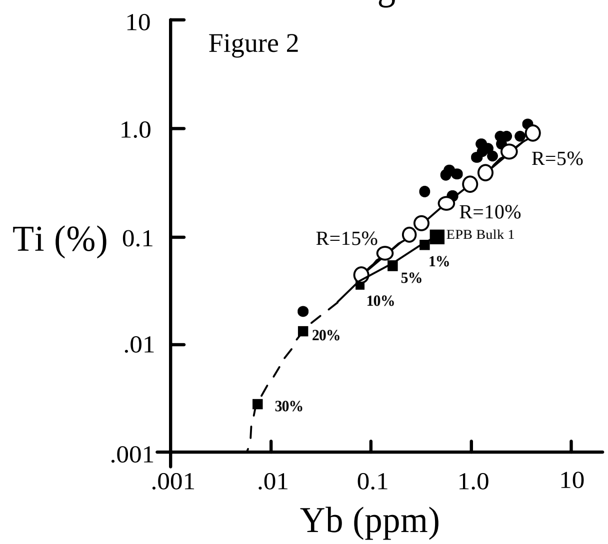


Figure 3